CMB B-modes, spinorial space-time and Pre-Big Bang (I)

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The BICEP2 collaboration reports a B-mode polarization of the cosmic microwave background (CMB) radiation inconsistent with the null hypothesis at a significance of $> 5\ \sigma$. This recent and potentially important result is being often interpreted as a signature of primordial gravitational waves from cosmic inflation. However, the arguments supporting such an interpretation are strictly based on standard cosmology and do not take into account possible new phenomena suggested by Planck data such as the existence of a privileged space direction. In particular, inflation is not needed in pre-Big Bang patterns, and the spinorial space-time (SST) introduced in our 1996-97 papers automatically generates a privileged space direction for each comoving observer. In the presence of this privileged space direction, the existence of CMB B-modes is a natural phenomenon and the signal claimed by BICEP2 would not correspond to any kind of inflationary scenario.

1. Introduction

BICEP2 data [1, 2] have given rise to speculations interpreting them as a strong direct evidence for cosmic inflation and primordial gravitational waves. The basic claim being that the detected B-modes of CMB cannot be generated primordially by density perturbations and that only gravitational waves originating from the inflationary expansion of the Universe can produce such a phenomenon.

However, this reasoning can apply only to cosmologies based on the standard Big Bang approach where inflation is required to get a potentially consistent description of the Universe. Pre-Big Bang models [3, 4] can easily escape these constraints and do not require any inflationary scenario. Furthermore, the spinorial space-time suggested in 1996-97 [5, 6] naturally generates [7, 8] a privileged space direction for each comoving observer. Then, the existence of CMB B-modes appears as a natural consequence of this local anisotropy.

The existence of a privileged space direction for each comoving observer may have been confirmed by recent Planck [9] results [10] after previous indications by WMAP [11]. Similarly, pre-Big Bang models can naturally solve the horizon problem [12] and provide reasonable alternatives to the inflationary explanation of the formation of conventional matter structure in our Universe.

In this short note, we remind and briefly discuss some basic elements of the obvious alternatives to the inflationary interpretation of BICEP2 results.

2. Pre-Big Bang

The pre-Big Bang scenarios considered here are not based on mere extrapolations from standard dynamics to higher energies and lower energy scales. We assume that really new physics is at work at distance and time scales smaller than the Planck scale, and that the standard principles of Physics (relativity, quantum mechanics...) cease to be valid at these scales [13, 14]. Then, new ultimate constituents of matter and a new space-time geometry can dominate this primordial phase of the history of the Universe.

If the new ultimate constituents of matter can travel at a speed much faster than light [12, 15], the very early Universe can naturally undergo a

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very fast expansion. Then, the horizon problem disappears and there is no longer any need for inflation. As standard matter will nucleate inside a pre-existing and quickly expanding universe with a pre-existing matter or pre-matter, fluctuations allowing for galaxy formation will be a natural phenomenon.

Contrary to the standard inflationary pattern, pre-Big Bang cosmologies do not need the Universe to be isotropic as seen by a comoving observer [7, 8]. The spinorial space-time provides an explicit example of a different scenario [3, 16]. Using a spinorial space-time appears as a natural choice, as the fermion wave functions do not correspond to representations of the real space rotation group SO(3) but of its covering group SU(2). Furthermore, Planck results suggest [10] that cosmic space anisotropy can indeed be a real feature of our Universe.

3. The spinorial space-time

The properties of the spinorial space-time have been reminded and further studied in [3, 16] and in [7, 8]. For a SU(2) spinor ξ describing space-time coordinates, a positive SU(2) scalar is $\mid \xi \mid^2 = \xi^\dagger \xi$ (the dagger stands for hermitic conjugate). Then, a definition of the cosmic time (age of the Universe) can be $t = \mid \xi \mid$ with an associated space given by the S^3 hypersphere $\mid \xi \mid = t$. Other definitions of t in terms of $\mid \xi \mid$ (f.i. $t = \mid \xi \mid^2$) lead to similar cosmological results as long as a single-valued function is used.

With the definition $t = \mid \xi \mid$, if ξ_0 is the observer position on the $\mid \xi \mid = t_0$ hypersphere, space translations inside this hypersphere correspond to SU(2) transformations acting on the spinor space, i.e. $\xi = U \xi_0$ where:

$$U = exp \ (i/2 \ \ t_0^{-1} \ \vec{\sigma}.\vec{\mathbf{x}}) \ \equiv U(\vec{\mathbf{x}}) \qquad (1)$$

$\vec{\sigma}$ being the vector formed by the usual Pauli matrices. The vector $\vec{\mathbf{x}}$ is the spatial position of ξ with respect to ξ_0 at constant time t_0.

The cosmic time origin (beginning of the Universe) is naturally associated to the point $\xi = 0$. This leads to an expanding Universe where cosmological comoving frames correspond to straight lines crossing the origin $\xi = 0$.

The privileged space direction associated to the space-time point ξ is then defined by the linear combination of sigma matrices (with real coefficients) that leaves ξ invariant. The space-time points on the trajectory generated by this sigma-like matrix satisfy the relation $\xi' = exp \ (i\phi) \ \xi$ where ϕ is real and $exp \ (i\phi)$ is a complex phase factor. Such a definition of a space trajectory is stable under SU(2) transformations and comoving time evolution.

Then, contrary to the standard isotropic situation where only E-modes associated to gradients can be present in the CMB except for the B-modes due to inflationary gravitational waves, the spinorial space-time easily leads to B-modes naturally generated by rotations around the privileged space direction and vector products by this direction. This is just a conservative example of the potentialities of new space-time geometries in pre-Big Bang cosmologies.

Thus, inflation is no longer necessary to explain the CMB B-modes that BICEP2 has possibly observed. On the contrary, such a result may have provided a signature of SST geometry or of some other unconventional structure beyond the standard space-time.

More details on the spinorial space-time can be found in [3, 4] and in [3, 16].

4. Conclusion

There is no serious reason to consider the possible existence of CMB B-modes suggested by BICEP2 data as an evidence for cosmic inflation rather than as a natural signature of a pre-Big Bang era or, simply, of a space-time geometry (the spinorial space-time) best adapted than the conventional real space-time to the existence of fermions among the elementary particles of standard Physics.

Planck results suggest that nonstandard cosmological phenomena may be at work. If confirmed, the BICEP2 result can be the beginning of a new evidence for physics beyond the standard model and cosmology beyond the present standard pattern based on ΛCDM and inflation.

The possibility that in pre-Big Bang and SST-like patterns the just nucleated standard mat-

ter reacts (including gravitationally) to the pre-existing fast expansion of the Universe has been explicitly considered in previous papers. See, for instance, the conclusion of [4].

Together with Planck, recent precise measurements may be providing evidence for new cosmology and a new fundamental space-time structure. A more detailed discussion of these important issues will be presented elsewhere.

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